Hydraulics

3rd Year civil

First Term (2009 - 2010)

Chapter (   )

2009 - 2010

1- Define: The permissible tractive force.
The critical tractive force.
Isovels.
2- State the factors that affect the velocity distribution in open channel.
3- Compare between hydraulically rough channel & hydraulically smooth channel.
4- The velocity distribution in a certain cross section show that the velocity equation at vertical section is given by:-

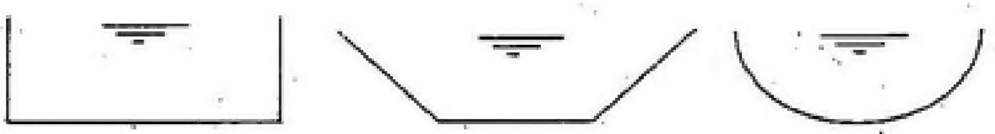
$$U = \frac{y_o^2}{4a}\left(1.4356 + 1.76\frac{y}{y_o} - \left(\frac{y}{y_o}\right)^2\right)$$

In which: $a = 0.0047 y S^{(-2/3)}$

y measured from the river bed, and y_o is the total depth.
Drive an expression for:-

a- Surface velocity. b- Bottom velocity.
c- Mean velocity. d- Maximum velocity.

5- Estimate the maximum shear stress on both the sides and the bottom ofatapezoidal open channel if, b=4y=10.0 m, n=0.015 , S=10.0 cm/km , Z=1.5, d_{50}=2.5mm , γsat.=1.8 t/m^3, and the angle of repose=38°, show how to check the stability of the hydraulic section. Calculate the maximum tractive force ratio and the shear velocity.
6- If Q=42 m^3/sec., Z=2, S=12 cm/km , d_{50}=4mm , Φ=30° , d_{90}=7mm , γsat=2.65, Design the canal section using the critical shear stress method.
7- In a river of bed width of 600 m and bed slope of 7.50 cm/km .It is found that the bed material just begin to move when the discharge is 120 million m3/day. Assuming the mean velocity to vary with the water depth and slope according to the relation, $V=120ys^{2/3}$, find the bed slope at which the same tractive force on the bed would be produced with a discharge of 365 million m^3/day.
8- Plot Isovels and shear stress distribution for the following sections.



$$n = \frac{D_{90}^{1/6}}{26}$$

بسم الله الرحمن الرحيم

Q(4):

$$u = \frac{y_o^3}{4a}\left[1.4356 + 1.76\frac{y}{y_o} - \left(\frac{y}{y_o}\right)^2\right]$$

y : measured from river bed.

y_o : total depth.

$$a = 0.0047\, y_o \cdot S^{-2/3}$$

Req.: Drive an expression for

a- surface velocity.

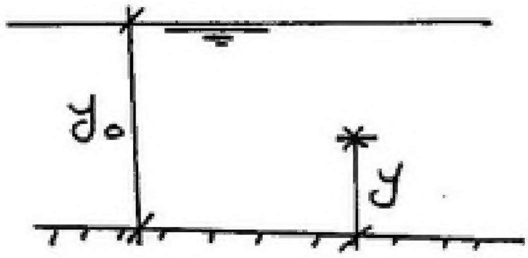
b- bottom velocity.

c- Max. velocity.

d- mean velocity.

Sol.:

For surface velocity:



$$y = y_o$$

$$\therefore\ u_{surface} = \frac{y_o^2}{4a}\left[1.4356 + 1.76\left(\frac{y_o}{y_o}\right) - \left(\frac{y_o}{y_o}\right)^2\right]$$

$$u_{surface} = \frac{y_o^2}{4a}\left[1.4356 + 1.76 - 1\right]$$

$$u_{surface} = 0.5489\,\frac{y_o^2}{a} \quad \#$$

For bottom velocity:

$$y = 0$$

$$u_{bottom} = \frac{y_o^2}{4a}\left[1.4356 + \cancel{1.76\left(\frac{0}{y_o}\right)}_{0} - \cancel{\left(\frac{0}{y_o}\right)^2}_{0}\right]$$

$$u_{bottom} = 0.3589\,\frac{y_o^2}{a} \quad \#$$

For max velocity :

$$\frac{du}{dy} = 0$$

$$0 = \frac{\cancel{y_o^2}}{\cancel{4a}}\left[0 + 1.76\left(\frac{1}{y_o}\right) - \frac{2y}{y_o^2}\right]$$

$$\frac{1.76}{y_o} = \frac{2y}{y_o^2}$$

$$\therefore 1.76\, y_o^{\cancel{2}} = 2\cancel{y_o}\, y$$

$$1.76\, y_o = 2y$$

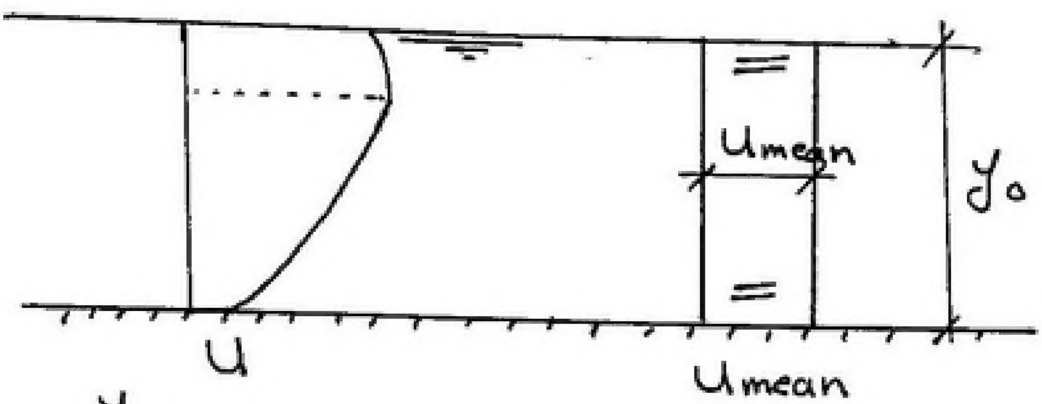
$$\boxed{y = 0.88\, y_o}$$

$$u_{max} = \frac{y_o^2}{4a}\left[1.4356 + 1.76 \times \frac{0.88 y_o}{y_o} - \left(\frac{0.88 y_o}{y_o}\right)^2\right]$$

$$u_{max} = \frac{y_o^2}{4a}\left[1.4356 + 1.76 \times 0.88 - 0.88^2\right]$$

$$u_{max} = 0.5525\, \frac{y_o^2}{a} \quad \#$$

For mean velocity:



$$\int_0^{y_o} U = y_o \times U_{mean}$$

$$U_{mean} = \frac{1}{y_o}\int_0^{y_o} U$$

$$U_{mean} = \frac{1}{y_o}\int_0^{y_o} \frac{y_o^2}{49}\left(1.4356 + \frac{1.76y}{y_o} - \frac{y^2}{y_o^2}\right) dy$$

$$U_{mean} = \frac{y_o}{49}\int_0^{y_o} 1.4356 + \frac{1.76y}{y_o} - \frac{y^2}{y_o^2} \; dy$$

$$= \frac{y_o}{49}\left[1.4356y + \frac{1.76y^2}{2y_o} - \frac{y^3}{3y_o^2}\right]_0^{y_o}$$

$$\therefore U_{mean} = \frac{y_o}{49}\left[1.4356y_o + \frac{1.76\cancel{y_o^2}}{2\cancel{y_o}} - \frac{\cancel{y_o^3}}{3\cancel{y_o^2}}\right]$$

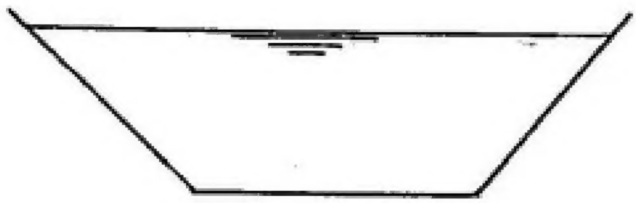
$$U_{mean} = \frac{y_o}{4a}\left[1.4356\, y_o + 0.88 y_o - \frac{y_o}{3}\right]$$

$$U_{mean} = \frac{y_o^2}{4a}\left[1.4356 + 0.88 - 0.33\right]$$

$$U_{mean} = 0.4964\ \frac{y_o^2}{a} \quad \#$$

Q(5):

Given:



- $b = 4y = 10 m$
- $n = 0.015$
- $S = 10\ cm/km$
- $Z = 1.50$
- $d_{50} = 2.5\ mm$, $\gamma_{sat} = 1.8\ t/m^3$
- $\phi = 38^\circ$

Req. :

1- τ_s , τ_b

2- check stability.

3- Tractive force ratio (K)

4- shear velocity (U_*)

Sol. :

(1) $\because b = 4y \Longrightarrow b = 10m$

$y = 2.5m$

$\because b = 4y$, $Z = 1.5$

$\therefore \tau_s = 0.75\ \gamma \cdot y \cdot S$

$= 0.75 \times 1000 \times 2.5 \times (10 \times 10^{-5})$

$\tau_s = 0.19\ kg/m^2$ #

$\because \tau_b = 0.97\ \gamma \cdot y \cdot S$

$= 0.97 \times 1000 \times 2.5 \times (10 \times 10^{-5})$

$$\tau_b = 0.24 \ kg/m^2 \ \#$$

(2)

$$\because d_{50} = 2.5 mm = 0.25 Cm$$

$$\therefore \tau_{cr} = 0.25 \ kg/m^2$$

$$\because \tau_s < \tau_{cr}$$

$$\tau_b < \tau_{cr}$$

section stable

(3)

$$\because K = \cos\theta \sqrt{1 - \frac{\tan^2\theta}{\tan^2\phi}}$$

$$\phi = 38^\circ$$

$$\theta = \tan^{-1}\frac{1}{1.5} = 33.7^\circ$$

$$\therefore K = \cos 33.7 \sqrt{1 - \frac{\tan^2 33.7}{\tan^2 38}}$$

$$\therefore K = 0.433 \quad \#$$

(4) $\because U_* = \sqrt{g \cdot R \cdot S}$

$\because A = (b + Zy)y = (10 + 1.5 \times 2.5) \times 2.5$

$A = 34.4 \ m^2$

$P = b + 2y\sqrt{1+Z^2} = 10 + 2 \times 2.5 \sqrt{1+1.5^2}$

$P = 19.0 m$

$$R = \frac{A}{P} = \frac{34.4}{19} = 1.81$$

$\therefore U_* = \sqrt{9.81 \times 1.81 \times (10 \times 10^{-5})}$

$\therefore U_* = 0.042 \ m/s$ #

Q(6) :

Given :

$\because Q = 42.0 \ m^3/s$

$Z = 2$

$S = 12 \ cm/km$

$d_{50} = 4 \ mm$, $d_{90} = 7 \ mm$

$\phi = 30°$, $\gamma_{sat} = 2.65$

Req. :

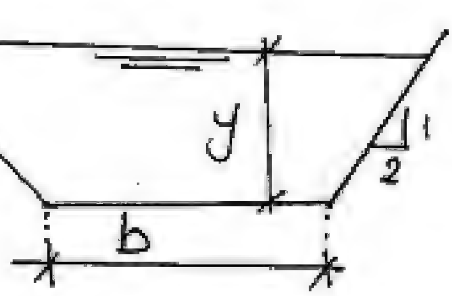
- Design section using critical shear stress method.

Sol. :

$\because d_{50} = 4 \ mm \Rightarrow \tau_{cr} = 0.4 \ kg/m^2$

assume

$\frac{b}{y} = 4$



$\tau_{s} = 0.76 \ \gamma \cdot y \cdot S$

$\tau_b = 0.98 \ \gamma \cdot y \cdot S$

for stability $\tau_s \ngtr \tau_{cr}$

$$\therefore 0.4 = 0.76 \times 1000 \times y \times (12 \times 10^{-5})$$

$$y = 4.40 \text{ m}$$

for stability $\tau_b \ngtr \tau_{cr}$

$$0.4 = 0.98 \times 1000 \times y \times (12 \times 10^{-5})$$

$$y = 3.40 \text{ m}$$

لضمان الاتزان نأخذ (y) الأقل .

$$\therefore \quad b = 4 \times 3.4 = 13.60 \text{ m}$$

$$\because Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

$$A = (13.6 + 2 \times 3.4) \times 3.4 =$$

$$A = 69.36 \text{ m}^2$$

$$P = 13.6 + 2 \times 3.4 \sqrt{1 + 2^2}$$

$$P = 28.80 \text{ m}$$

$$\therefore \boxed{n = \frac{(d_{90})^{1/6}}{26}}$$

$$n = \frac{(0.007)^{1/6}}{26} = 0.0168$$

$$\therefore Q = \frac{1}{0.0168} \times \frac{(69.36)^{5/3}}{(28.8)^{2/3}} \times (12 \times 10^{-5})^{1/2}$$

$$Q = 81.30 \ m^3/s > Q_{given}$$

(safe)

ملحوظة

فى حالة ان التصرف الناتج كان أقل من التصرف المعطى فى المسأله.

يتم فرض نسبه جديده لـ $\frac{b}{y}$

وكذلك تغيير قيم τ_s ، τ_b

وتكرار الخطوات مره اخرى

Q(7) :

Given :

- $B = 600$ m , $\bar{S} = 7.5$ cm/km
- $Q = 120$ million m^3/day
- $V = 120 \cdot y \cdot S^{2/3}$

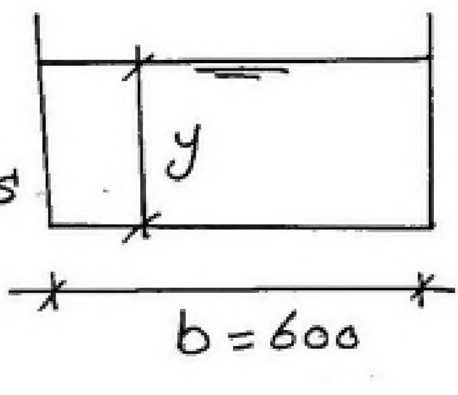
Req. :

(a) $\bar{S} = ??$
which give the same tractive force on bed with $Q = 365$ million m^3/d

Sol. :

for $Q = 120 \times 10^6$ m^3/d

$\because Q = A \times V$



$$Q = \frac{120 \times 10^6}{24 \times 60 \times 60} = 1388.9 \ m^3/s$$

$$A = 600 \ y$$

$$1388.9 = (600\,y) \times 120\,y \times (7.5\times10^{-5})^{2/3}$$

$$y = 3.30\ m$$

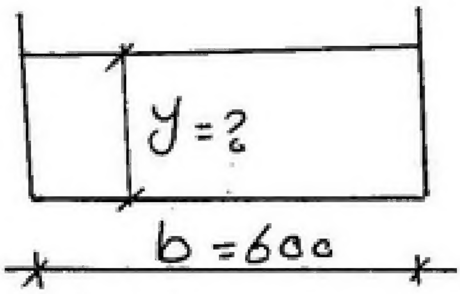
$$\because\ \tau = \gamma \cdot y \cdot S$$

$$\therefore\ \tau = 1000 \times 3.30 \times (7.5\times10^{-5})$$

$$\tau = 0.25\ kg/m^2$$

<u>for $Q = 365\times10^{6}\ m^3/d$</u>

$$\because\ V = 120 \cdot y \cdot S^{2/3}$$



$$\tau_{old} = \tau_{new}$$

$$0.25 = 1000 \times y \times S \longrightarrow \boxed{1}$$

$$\because\ Q = A \times V$$

$$A = 600\,y$$

$$\because\ Q = \frac{365\times10^{6}}{24\times60\times60} = 4224.5\ m^3/s$$

$$\therefore 4224.5 = (600y) \times 120y \times S^{2/3}$$

$$0.059 = y^2 \cdot S^{2/3} \longrightarrow \boxed{2}$$

from $\boxed{1}$ $\quad y = \frac{0.25}{1000 S}$

subis in $\boxed{2}$

$$0.059 = \left(\frac{0.25}{1000 S}\right)^2 \times S^{2/3}$$

$$944000 = \frac{S^{2/3}}{S^2} = \frac{S^{2/3}}{S^{6/3}}$$

$$944000 = S^{-4/3}$$

$$S = 3.3 \times 10^{-5} \#$$

$$y = 7.60 m \#$$